Imágenes BG&P

Tool Steel

Diagrama de Fases seudobinario

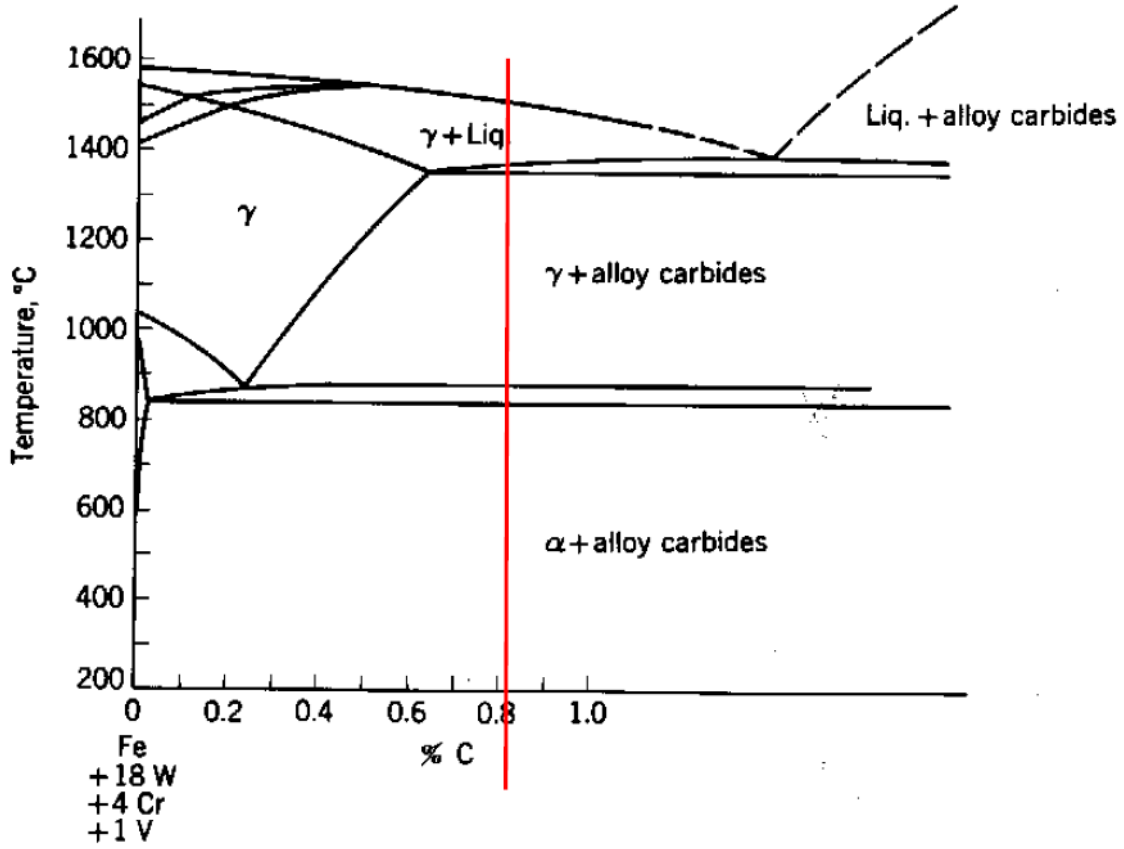


FIG. 11.2. Isothermal transformation diagram for a water-hardening plain-carbon tool steel austenitized according to the usual hardening treatment at 790°C; therefore from the $\gamma + Fe_3C$ field with undissolved carbides in the structure. Rockwell hardnesses of transformation structures are shown. The degree of transformation of austenite to martensite, shown by dashed lines, may vary with cooling rate (or relatedly, cooling stresses) in large sections. The 95% transformed at the right end of the 80% horizontal (150°C) means 80% martensite + 15% bainite, since long holding here would cross the bainite transformation line if that were extended below 200°C.

TTT isotérmico de Acero tipo W templado desde campo bifásico (790°C)

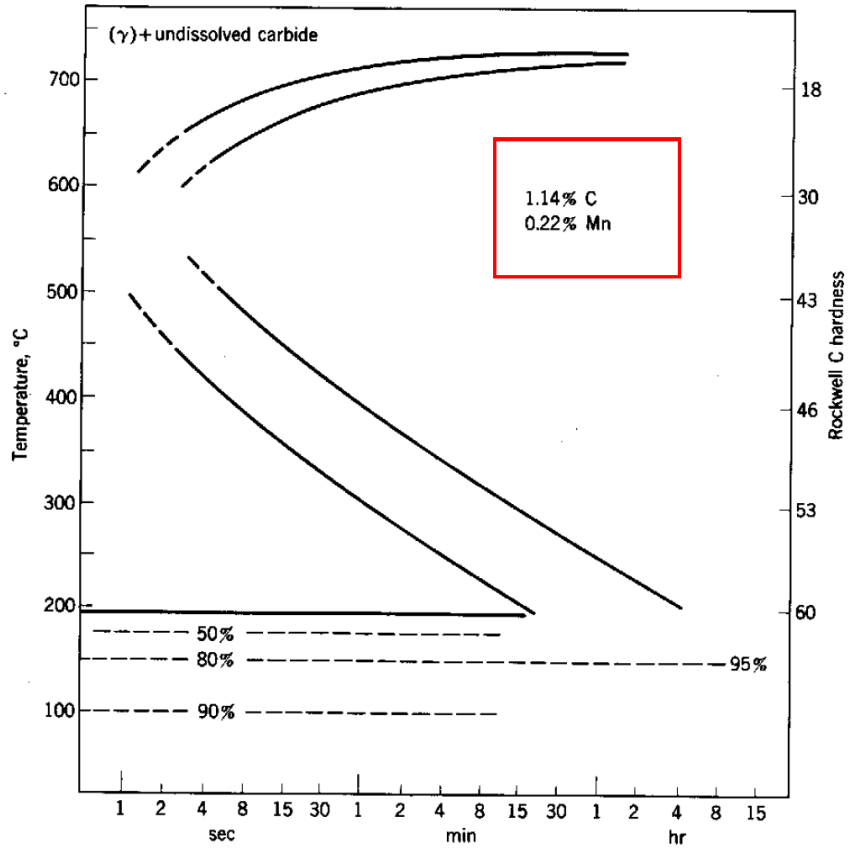


Table 11.2 Effect of austenitization treatment on martensite reaction of carbon tool steel

	Austenitization treatment		
	790°C, 1 hr	830°C, ½ hr	870°C, ½ hr
γ grain size, ASTM	No. 9	No. 8	No. 6
Undissolved carbides	Very many	Many	Some
% Martensite at 150°C	80	40	5
% Martensite at 100°C	90	80	50
% Martensite at 30°C	100	95	85

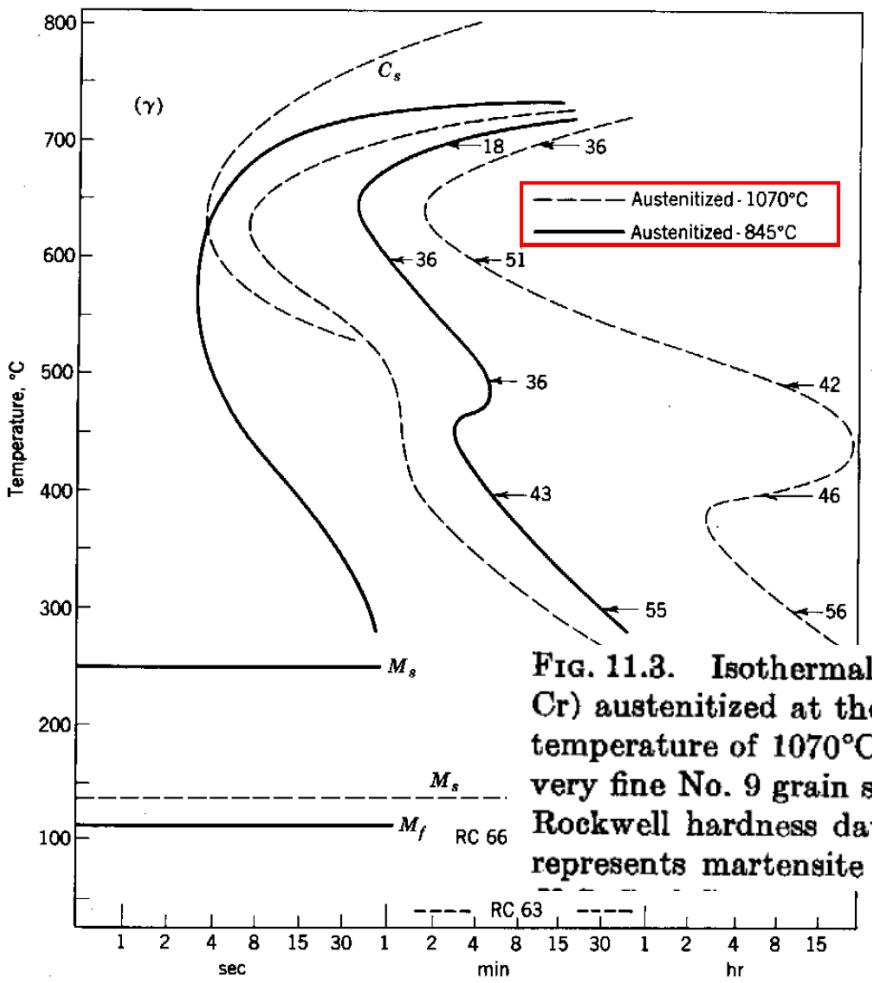
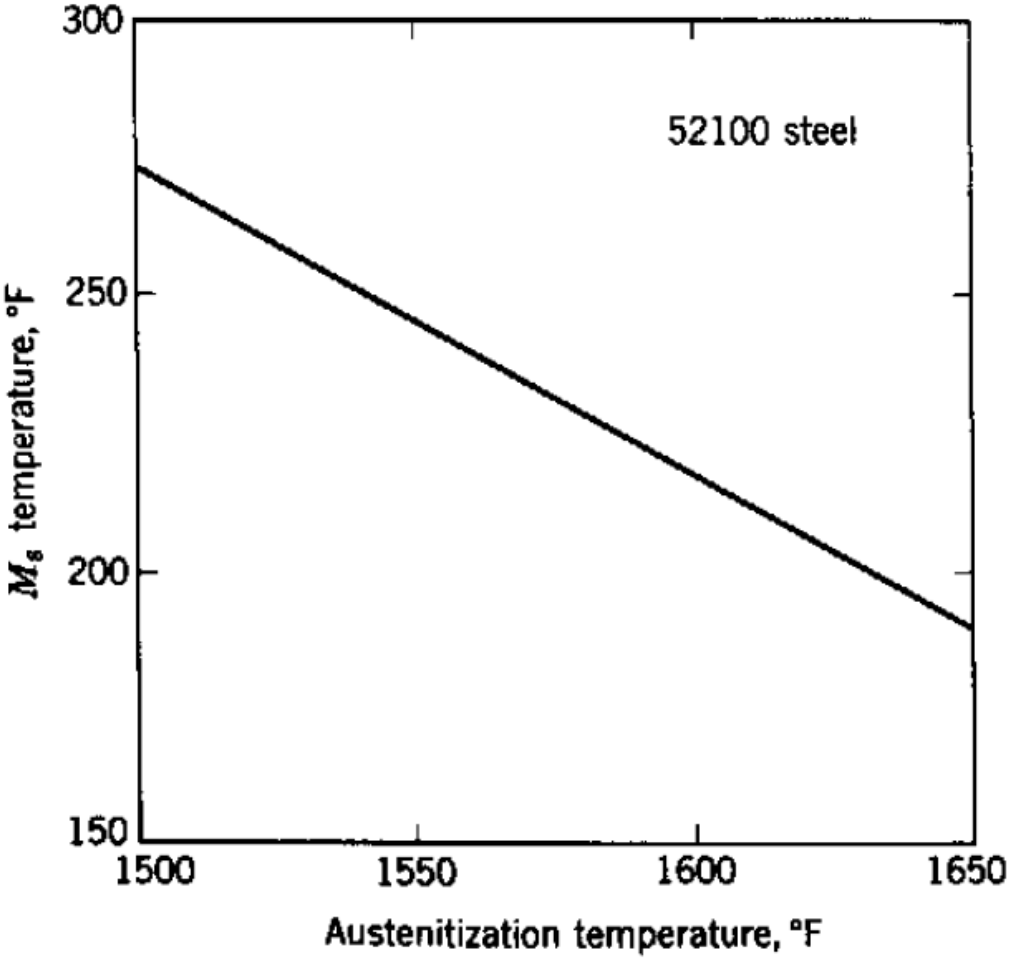


FIG. 11.3. Isothermal transformation diagram for steel AISI 52100 (1.02% C, 1.41% Cr) austenitized at the normal hardening temperatures, 845°C (solid line), and at a temperature of 1070°C, sufficiently high to dissolve all carbides. The 845°C gave a very fine No. 9 grain size, while the 1070°C treatment resulted in a No. 3 grain size. Rockwell hardness data are shown; the quenched RC63 for the 1070°C treatment represents martensite plus soft retained austenite. (*Atlas of Isothermal Diagrams,*

Table 11.3 Effect of austenitization treatment on martensite reaction in oil-hardening nondeforming steel

	Austenitization treatment			
	790°C, 1 hr	870°C, ¾ hr	980°C, ¾ hr	1095°C, ½ hr
γ grain size, ASTM	No. 9	No. 6	No. 5	No. 2
Undissolved carbides	Very many	Few	None	None
% Martensite at 150°C	80	10	10	10
% Martensite at 100°C	95	40	40	40
% Martensite at 30°C	99	90	80	80


300
250
200
150
52100 steel
M_s temperature, °F
1500
1550
1600
1650
Austenitization temperature, °F

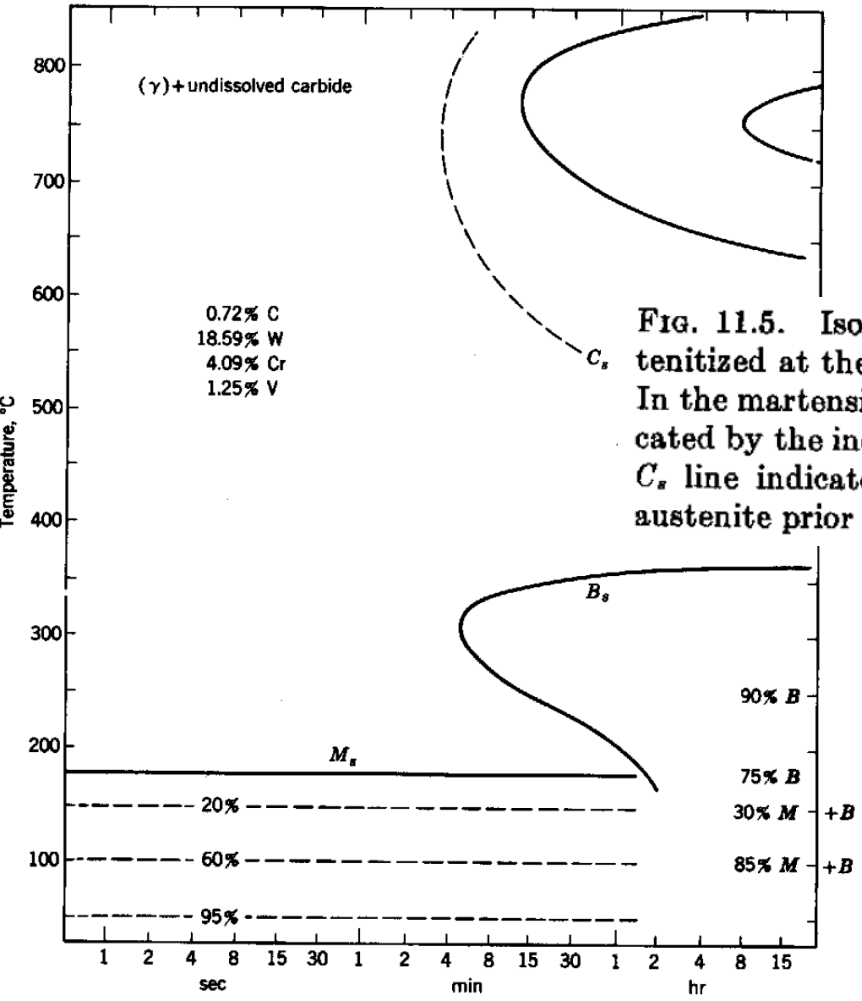


FIG. 11.5. Isothermal transformation diagram for 18-4-1 high-speed steel as austenitized at the usual hardening temperature of 1290°C from an annealed structure. In the martensitic formation range, long-time holding permits bainite to form as indicated by the increased percentage transformation at long times (15 hr). The dashed C_s line indicates approximate start for carbide precipitation from supersaturated austenite prior to the eutectoid reaction.

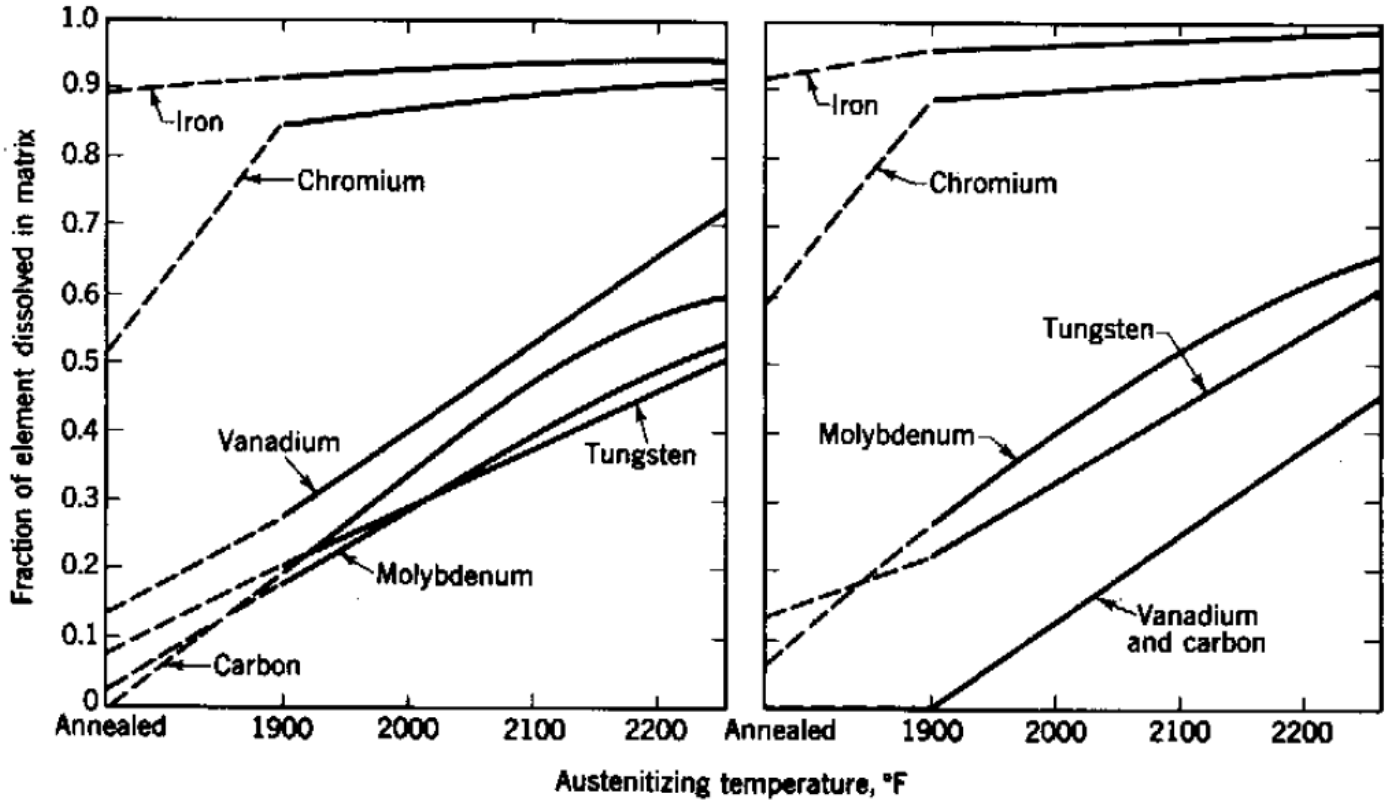


FIG. 11.6. Partition of elements between matrix and carbides in high-speed steels, M1 (left) and M4. Most of the chromium carbides are dissolved at 1900°F; vanadium, molybdenum, and tungsten carbides dissolve much more slowly.

Table 11.4 Effect of austenitization treatment on martensite reaction in air-hardening high-carbon high-chromium steel

	Austenitization treatment			
	1010°C, 1 hr	1070°C, ½ hr	1110°C, ¼ hr	1150°C, 5 min
γ grain size, ASTM	No. 11	No. 10	No. 9½	No. 9
% Martensite at 95°C	95	20	Trace	0
% Martensite at 30°C	100	85	30	Trace
Rockwell hardness as quenched	C65	C59	C47	C36

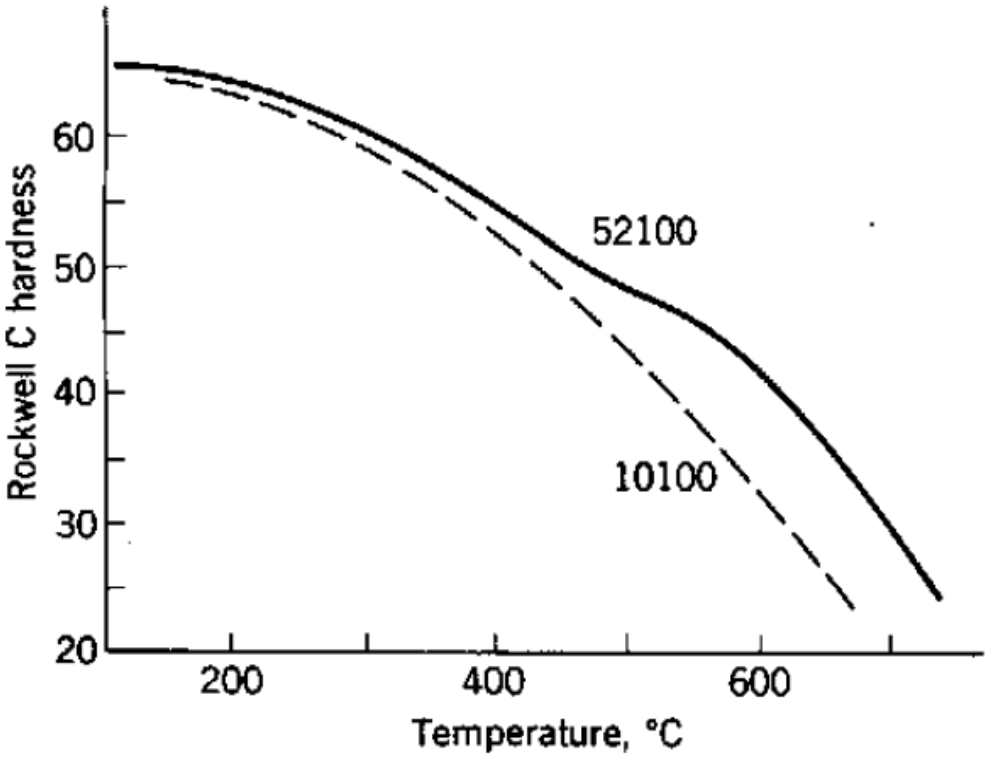
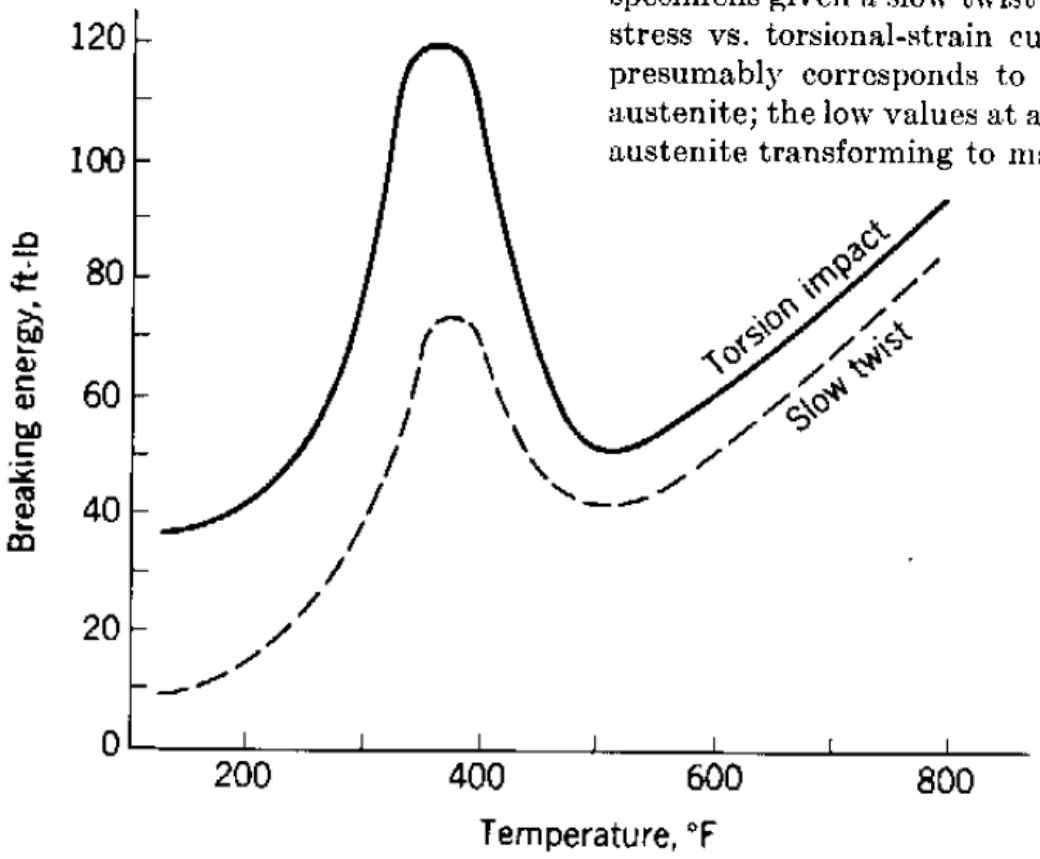


FIG. 11.7. Tempering data for a plain high-carbon steel, water-quenched from 790°C, and for 52100 (1% C and 1.2% Cr) after being quenched in oil from 845°C. Tempering time for both curves was 1 hr.

FIG. 11.8. Energy required to break tempered martensitic structures as a function of the tempering temperature. The 1.1% C tool steel was quenched in brine from 1450°F and tempered for 1 hr at the indicated temperatures. The breaking energy for the specimens given a slow twist was obtained by integrating the area under the torsional-stress vs. torsional-strain curve for each test specimen. The peak at about 375°F presumably corresponds to stress relief of martensite, with no change of retained austenite; the low values at about 500°F result from the stresses generated by retained austenite transforming to martensite upon cooling from the tempering operation.



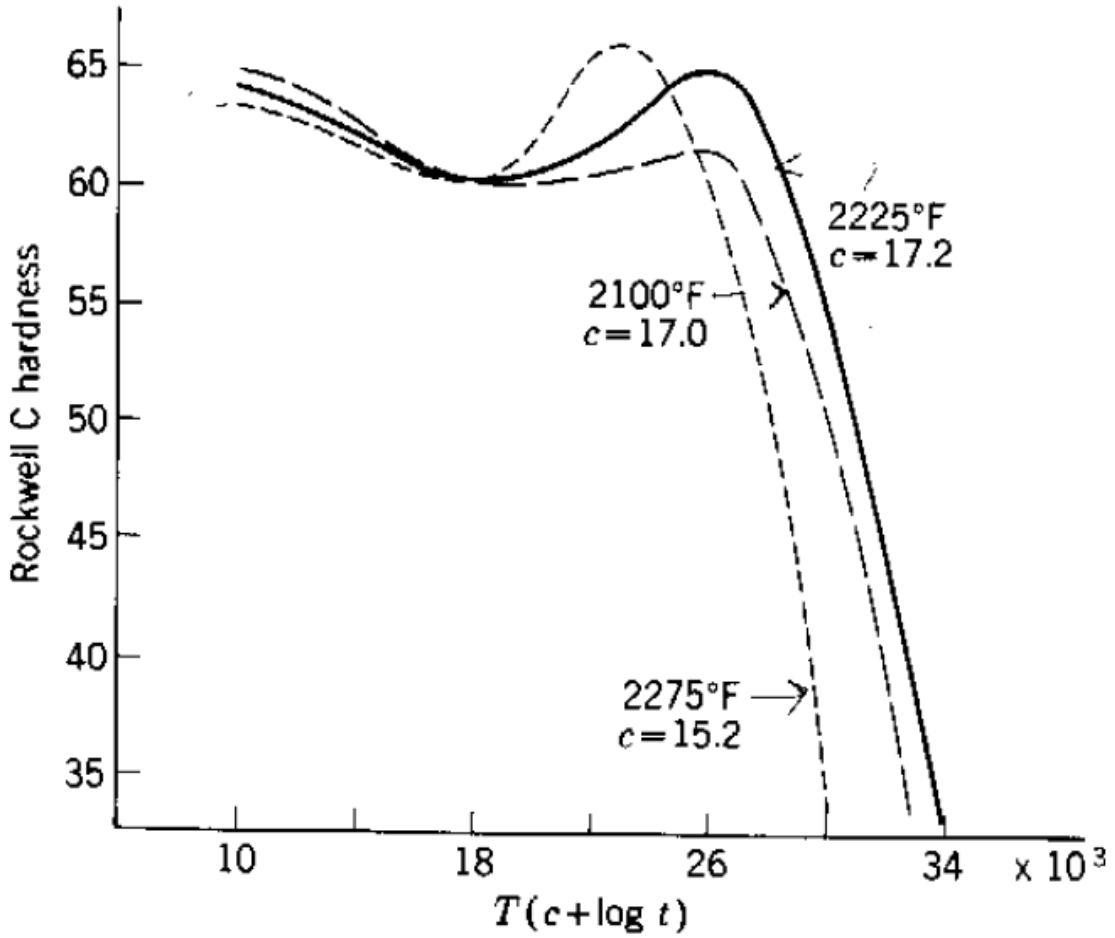


FIG. 11.9. Tempering curves for 6-5-4-2 high-speed steel austenitized at three different temperatures. Tempered hardness is plotted against the parameter $T(c + \log t)$, where T is the tempering temperature, t the tempering time, and c a constant for a specific steel and austenitization treatment. (*Roberts, Grobe, and Moersh.*)

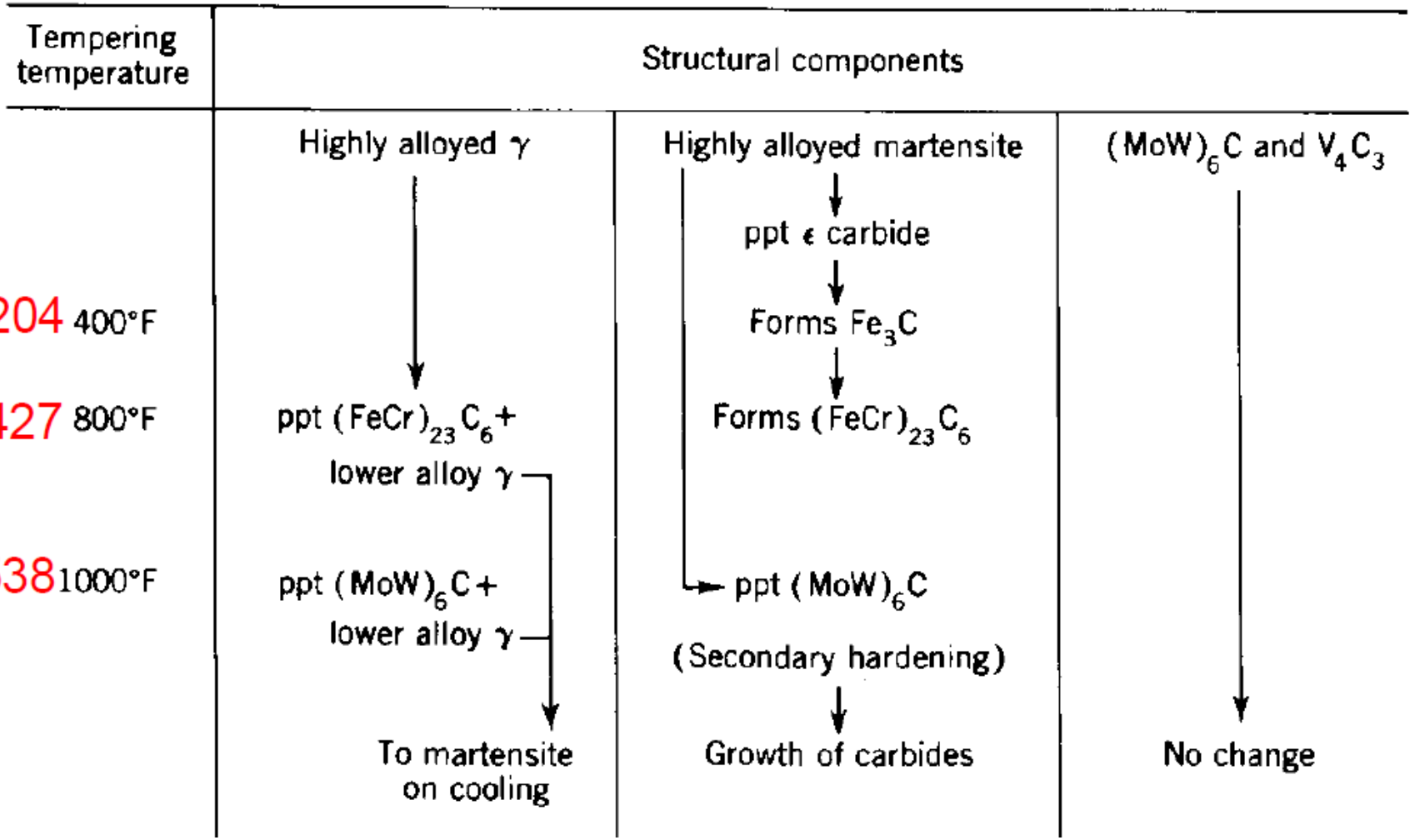

Tempering temperature
Structural components
Highly alloyed γ
Highly alloyed martensite
(MoW)6C and V4C3
ppt ε carbide
Forms Fe3C
204 400°F
427 800°F
ppt (FeCr)23C6+
lower alloy γ
Forms (FeCr)23C6
538 1000°F
ppt (MoW)6C+
lower alloy γ
ppt (MoW)6C
(Secondary hardening)
To martensite on cooling
Growth of carbides
No change

FIG. 11.10. Tempering curves for 18-4-1 high-speed steel, quenched in oil from the usual hardening temperature of 2350°F; curves for hardness after tempering 6, 60, and 6000 min are reproduced. Almost identical tempering curves are obtained for the 6-5-4-2 high-speed steel when oil-quenched from its usual hardening temperature of 2225°F. *(Roberts, Grobe, and Moersh.)*

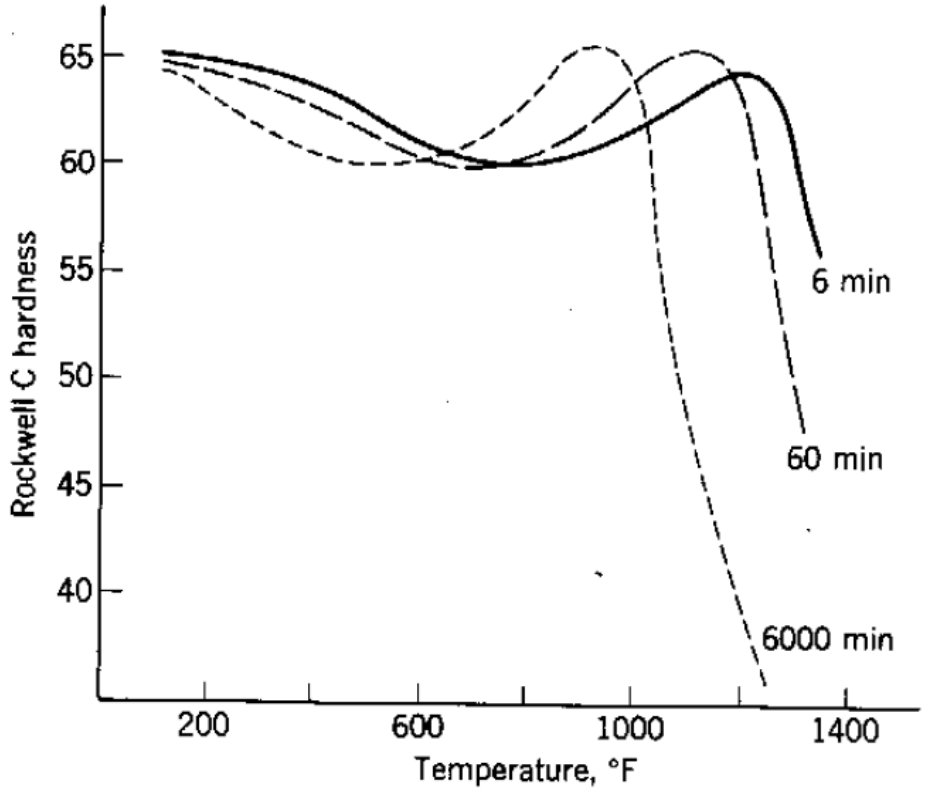


FIG. 11.11. Tempering curves for an air-hardening die steel austenitized at three different temperatures, as indicated on each curve. Tempered hardness is plotted against the parameter $T(c + \log t)$, where T is the tempering temperature, t is the tempering time, and c is a constant for each curve whose value depends on the austenitization temperature. Hardening from the lowest temperature results in no secondary hardening; hardening from the highest temperature results in low initial hardness because of retained austenite and then a related pronounced secondary hardening. *(Roberts, Grobe, and Moersh.)*

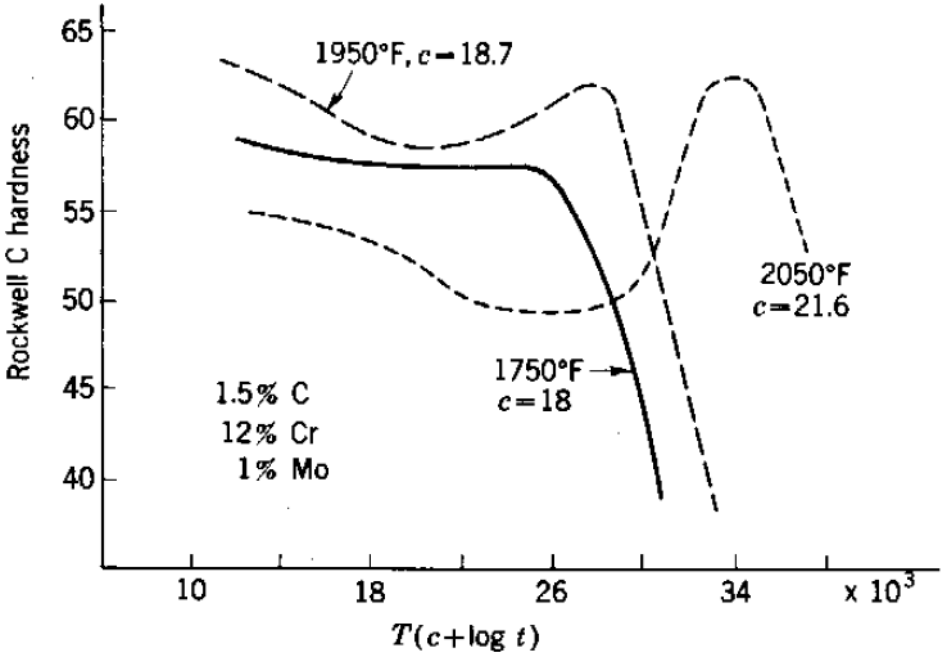
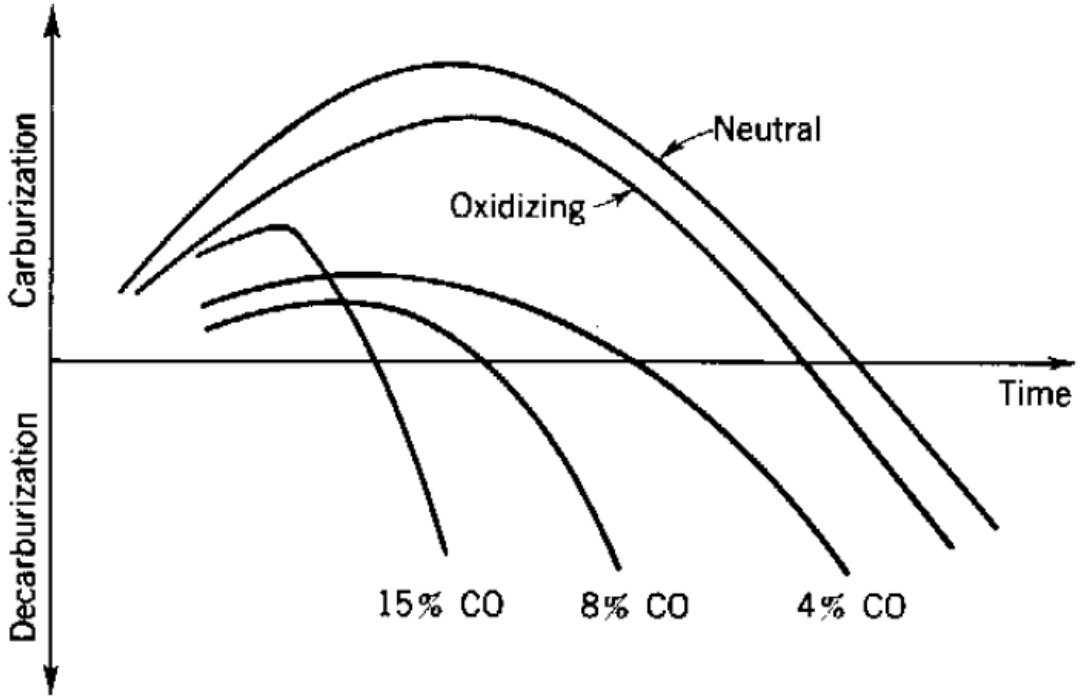



FIG. 11.12. Surface carbon effects on high-speed steel of different atmospheres with increasing time at the austenitizing temperature. The "neutral" atmosphere would be completely burnt gas with no excess oxygen. The oxidizing atmosphere would be gas burnt with an excess of air. The varying percentages of carbon monoxide would be atmospheres of gas burnt with insufficient air. Therefore, all atmospheres for this schematic graph contain CO_2 and H_2O as well as CO or O. (*Schlegel.*)